08/550150

APPLICATION FOR LETTERS PATENT OF THE UNITED STATES

CERTIFICATE OF MAILING BY "EXPRESS MAIL"
"EXPRESS MAIL" Mailing Label Number TB875403980US
Date of Deposit October 30, 1995
I hereby certify that this paper or fee is being deposited with the United States Postal Service "EXPRESS MAIL POST OFFICE TO ADDRESSEE" Service under 37 CFR 1.10 on the date indicated above and is addressed in the Commissioner of Patents and Trademarks, Washington, D.C. 20231
Karen A. Church
(Typed or Printed Name of Person Mailing Paper or Fee)
Karen A. Church
(Signature of Person Mailing Paper or Fee)

SPECIFICATION

To all whom it may concern:

Be It Known, That we, **Paul O. Detwiler,** and **Barry M. Mergenthaler**, citizens of the United States, and **Hong Tang**, a citizen of the People's Republic of China; residing at Lawrenceville, Georgia; Lawrenceville, Georgia; and Suwanee, Georgia; respectively, have invented certain new and useful improvements in an **OPTICAL SCANNER HAVING ENHANCED ITEM SIDE COVERAGE**, of which we declare the following to be a full, clear and exact description:

08/550150 A

OPTICAL SCANNER HAVING ENHANCED ITEM SIDE COVERAGE

Background of the Invention

The present invention relates to optical scanners and more specifically to an optical scanner having enhanced item side coverage.

U.S. Patent No. 5,229,588 to Detwiler et al. discloses a dual aperture optical scanner which includes horizontal and vertical apertures. The scanning light beams from a single laser diode pass through these apertures to provide coverage for up to four sides of a scanned item: the side facing the vertical aperture (front), the side facing the horizontal aperture (bottom), and the left and right sides.

While this scanner requires much less item orientation than a single aperture scanner, it is not capable of scanning the top and rear sides of scanning items. Therefore, it would be desirable to provide an optical scanner which is capable of scanning as many as five sides of a typical merchandise item.

Summary of the Invention

In accordance with the teachings of the present invention, an optical scanner having enhanced item side coverage is provided. The optical scanner preferably also

includes a housing having first and second apertures, a laser beam source, a mirrored spinner for reflecting the laser beam in a plurality of directions, and a plurality of pattern mirrors within the housing for reflecting the laser beam from the spinner through the first and second apertures to an article having a bar code label to be scanned. Preferably, the first aperture is substantially horizontal and the second aperture is substantially vertical to maximize scan pattern coverage and to minimize required item orientation.

The optical scanner also preferably includes an optical transceiver for passing the laser beam and for collecting reflected light from the scanned article and a photodetector for generating signals representing the intensity of the light reflected from the article.

The scanner of the present invention produces horizontal, vertical, and diagonal scan patterns. A first set of pattern mirrors is positioned adjacent the horizontal aperture. A second set of pattern mirrors is positioned adjacent the vertical aperture and includes first, second, and third subsets of pattern mirrors. The spinner reflects a first group of scanning beams across the first set of pattern mirrors and out the first window, reflects a second group of scanning beams across the first and third subsets of pattern mirrors and out the second window, and reflects a

third group of scanning beams across the second and third subsets of pattern mirrors and out the second window.

It is a feature of the present invention that the mirrored spinner and pattern mirrors combine to produce a plurality of scan lines which pass through the horizontal and vertical apertures. The scanner produces a scan pattern which more effectively covers multi-sided articles than single aperture scanners. The mirrored spinner includes four facets which are oriented at different angles with respect to a predetermined reference. The pattern mirrors are flat and include a first set of mirrors for reflecting the laser beam from the spinner, a second set of mirrors for reflecting the laser beam from the first set of mirrors, and for some scan lines, a third set of mirrors for reflecting the laser beam from the second set of mirrors. Preferably, the optical scanner produces forty scan lines.

It is accordingly an object of the present invention to provide an improved dual aperture optical scanner having enhanced item coverage.

It is another object of the present invention to provide an improved dual aperture optical scanner in which a first aperture is substantially vertical and a second aperture is substantially horizontal.

It is another object of the present invention to provide a dual aperture optical scanner which substantially

increases the illuminated surface area of an article to be scanned.

It is another object of the present invention to provide a dual aperture optical scanner which may suitably employ a single laser and motor for cost conscious applications in which cost may be design determinant.

Brief Description of the Drawings

Additional benefits and advantages of the present invention will become apparent to those skilled in the art to which this invention relates from the subsequent description of the preferred embodiments and the appended claims, taken in conjunction with the accompanying drawings, in which:

Fig. 1 is a block diagram of the optical scanner having enhanced item side coverage of the present invention;

Fig. 2 is an exterior perspective view of the scanner of the present invention, including a reference coordinate system for the group of pattern mirrors within the scanner of the present invention;

Fig. 3 is an interior perspective view of the scanner of the present invention;

Fig. 4 is a sectional view of the scanner of the present invention along lines 4-4 of Fig. 3;

Fig. 5 is a reference coordinate system for determining one-suitable orientation for the group of pattern mirrors within the scanner of the present invention;

Fig. 6 is a plan view of the scan pattern emanating upwardly from a horizontal aperture;

Fig. 7 is a plan view of a first scan pattern emanating outwardly from a vertical aperture;

Fig. 8 is a plan view of a second scan pattern emanating outwardly from the vertical aperture;

Fig. 9 is a plan view of the combined first and second scan patterns of Figs. 7 and 8; and

Fig. 10 is a perspective view of a laser assembly showing two lasers.

Detailed Description of the Preferred Embodiment

Referring now to Fig. 1, a point-of-service (POS) system 10 includes optical scanner 11 and POS terminal 13.

POS terminal 13 receives transaction data, for example, in the form of SKU numbers from scanner 11 and completes a transaction by finding price data for the SKU numbers in a price-lookup data file.

Scanner 11 of the present invention includes laser 12, optical transceiver 14, mirrored spinner 16, pattern mirrors 18, deflector mirror 19, photodetector 20, and

control circuit 21. Laser 12 includes a laser diode or other suitable laser source.

A focusing lens or lenses and a collimating aperture are also preferably used to produce a focused and collimated laser beam 22. In the preferred embodiment, the laser diode emits visible light within a wavelength range of 670-690nm and the collimating aperture and focusing lens produce a beam 22 having a beam waist of 220 microns in the center of the read zone. Other wavelengths and beam waists may be suitably employed.

Beam 22 passes through optical transceiver 14, which includes a mirrored collecting surface and an aperture for passing beam 22. The mirrored collecting surface preferably has an ellipsoidal or other curved surface.

Beam 22 contacts mirrored spinner 16, which preferably has four planoreflective mirrored facets 108-114 for producing scanning beams 24 (Fig. 3). Four facets were chosen as an optimal compromise between the increased line length created by using three facets and the increased rastering provided by spinners having more than four facets.

Scanning beams 24 impact pattern mirrors 18, which produce a plurality of scan lines 26. In the preferred embodiment, pattern mirrors 18 are preferably flat and produce forty scan lines 26 for each complete revolution of mirrored spinner 16. Advantageously, all forty scan lines

26 are preferably produced by only one laser 12 and motor 17. Use of a greater or lesser number of scan lines and pattern mirrors will be apparent to those skilled in the art.

Some scan lines 26 pass through a substantially horizontal aperture 28 and some pass through a substantially vertical aperture 30 in scanner housing 32 on their way to bar code label 34 on merchandise item 36. Substantially vertical aperture 30 is preferably oriented at 5¾ degrees from a vertical plane. The choice of angle is chosen to optimize the scan volume and line length of the scan lines. It is desirable to achieve a ratio of the minimum length of the longest scan line to the maximum length of the shortest scan line as close as possible to one. At about ten degrees, scanning is adversely impacted for the configuration of pattern mirrors 18 illustrated herein.

According to the present invention, scan lines 26 are divided into three groups. Scan lines within a first group (Group I) emanate outwardly and downwardly from vertical aperture 30 to illuminate the top and customer sides of an item.

Scan lines within a second group (Group II) emanate outwardly from aperture 30 as three sub-groups to illuminate the customer side (Sub-group IIa), the customer

and leading sides (Sub-group IIb), and customer and trailing sides (Sub-group IIc).

Scan lines from the third group (Group III) emanate upwardly from horizontal aperture 28 as three sub-groups to illuminate the bottom (Sub-group IIIa), leading side (Sub-group IIIb), and trailing side (Sub-group IIIc).

Reflected light 37 is redirected by pattern mirrors 18 towards spinner 16, which further directs it towards optical transceiver 14. Optical transceiver 14 directs and focuses reflected light 37 at deflector mirror 19, which further directs reflected light 37 towards photodetector 20. Photodetector 20 generates electrical signals representing the intensity of reflected light 37.

Control circuitry 21 decodes bar code label 34 and controls power to laser 12 and motor 17. Control circuitry 21 may remove power from laser 12 and motor 17 to increase the longevity of laser 12 and motor 17. When scanner 11 is equipped with two lasers (Fig. 10), control circuitry 21 alternates power removal from lasers 140 and 142. For example, control circuitry 21 may remove power from laser 140 during one complete revolution of spinner 16, and remove power from laser 142 during the following revolution.

Turning now to Fig. 2, scanner 11 is shown in perspective. Horizontal aperture 28 is located within substantially horizontal surface 38 of housing 32. Vertical

aperture 30 is located within substantially vertical surface 40.

Preferably, scanner 11 may be easily adapted to fit in a typical checkout counter 42. Standard dimensions for apertures in checkout counters like checkout counter 42 are about eleven inches in length (i.e., in the direction of item flow), twenty inches in width (i.e., in the direction across the direction of item flow), and five inches deep. Thus, despite its improved scan coverage, scanner 11 easily fits within standard apertures. This is due to the optimal size and arrangement of components within scanner 11.

It is envisioned that top surface 38 be made substantially flush with the top surface 44 of counter 42, and also include a scale 43. Scanner 11 is installed within checkout counter 42 so that substantially vertical aperture 30 faces a store employee.

Referring now to Figs. 3 and 4, the presently preferred arrangement of scanner components is shown in more detail. Laser 12 is preferably oriented at thirty-five degrees from the horizontal or X-axis as shown in Fig. 2. Laser 12 is mounted within a bracket 15 which attaches to the lower wall of scanner 11. Beam 22 contacts planoreflective surfaces 108-114 of mirrored spinner 16 (Fig. 4). Spinner axis 116 is preferably oriented at twenty-two and a half degrees from a vertical or Z-axis.

Facets 108-114 are preferably oriented at two and half degrees, four degrees, seven degrees, and eight and a half degrees, respectively, from spinner axis 116. These angles cause spinner 16 to generate four different sets of scan lines (Table III below) and are chosen to balance spinner 16 as much as possible consistent with the goal of generating four different sets of scan lines.

Pattern mirrors 18 are all preferably flat mirrors. Scanning beams 24 from spinner 16 impact a first set of mirrors 50-72 and reflect therefrom to a second set of mirrors 74-98. Mirrors 80-98 within the second set further direct beams 24 to a third set of mirrors 100-106.

The reference coordinate system for mirrors 50-106 is shown in Figs. 2 and 5, and includes X, Y, and Z axes, with the Z-axis being out of the page. Coordinates Xm, Ym, and Zm are measured in inches, and angles Xr and Yr, are measured in degrees, with positive angles being measured in a counter-clockwise direction. Pattern mirrors 18 are positioned or located with respect to this coordinate system as described below. Each mirror is first oriented parallel to the X-Y plane through a point (Xm, Ym, Zm). Each mirror is rotated through an angle Xr about a line X' parallel to the X-axis and containing the point (Xm, Ym, Zm). Each mirror is rotated through an angle Yr about a line Y' parallel to the Y-axis and containing the point (Xm, Ym,

Zm). Thus, these five variables uniquely define planes for mirrors 50-106 and are shown in Table I. Presently preferred values are shown.

Origin O is defined such that:

X=0 is on the centerline of the scanner;

Z=0 is on the centerline of the scanner; and

Y=0 is on the substantially horizontal surface 38.

T120X

Table I:

Mirror	Xm	Ym	Zm	Xr	Yr
50	+3.375	-0.825	+3.200	+19.50	-108.50
52	+4.200	-0.825	+0.010	+24.00	-100.00
54	+4.200	-0.825	-0.010	+24.00	-80.00
56	+3.375	-0.825	-3.200	+19.50	-71.50
58	-3.400	-2.010	+4.345	+14.00	-168.25
60	-3.400	-2.010	-4.345	+14.00	-11.75
62	-3.905	-1.635	+3.850	-11.00	-125.00
64	-2.950	-3.410	+1.030	+21.50	-85.00
66	-2.950	-3.410	-1.030	+21.50	-95.00
68	-3.905	-1.635	-3.850	-11.00	-55.00
70	-5.430	-0.050	+4.720	+30.00	-132.50
72	-5.430	-0.050	-4.720	+30.00	-47.50
74	-1.315	-2.300	+4.585	-30.00	-167.25
76	+4.900	-4.725	+0.000	-77.50	+90.00
78	-1.315	-2.300	-4.585	-30.00	-12.75

Mirror	Xm	Ym	Zm	Xr	Yr
80	-5.185	-3.095	+3.795	-60.00	+77.50
82	-4.880	-2.910	+3.685	-66.00	+102.50
84	-4.600	-3.155	+4.040	-52.25	+136.25
86	-4.600	-3.165	+4.040	-58.75	+149.00
88	-4.600	-3.165	-4.040	-58.75	+31.00
90	-4.600	-3.155	-4.040	-52.25	+43.75
92	-5.185	-3.095	-3.795	-60.00	+102.50
94	-4.880	-2.910	-3.685	-66.00	+77.50
96	-7.515	+0.485	+0.060	-37.00	+67.50
98	-7.515	+0.485	-0.060	-37.00	+112.50
100	-3.745	+6.250	+2.610	+50.00	+137.50
102	-6.420	+4.900	+0.000	+38.25	+90.00
104	-3.165	+6.275	+0.000	+69.25	+90.00
106	-3.745	+6.250	-2.610	+50.00	+42.50

Table II shows orientation and location data for the laser, spinner, and photodetector:

T130X

Table II:

Component	Xm	Ym	Zm
Laser	-4.050	-3.940	+0.000
Spinner	-6.875	-2.175	+0.000
Photodetector	-4.645	-4.580	+0.000

In operation, laser beam 22 strikes each facet of mirrored spinner 16 in sequence. Table III summarizes the facet and mirrors involved in generating the forty scan lines (Figs. 6-9) during one revolution of spinner 16. The forty scan lines are arranged in the sequence in which they are generated as spinner 16 rotates in a counter-clockwise direction as viewed from above.

Table III:

T140X

Scan Line	Facet	Primary Mirror	Secondary Mirror	Tertiary Mirror	Group	Sub-group
H1	108	70	82	104	I	
O1	108	62	96	102	II	IIa
L1	108	64	86	104	I	
E1	108	50	76		III	IIIa
D1	108	52	76		III	IIIa
B1	108	54	76		III	IIIa
C1	108	56	76		III	IIIa
N1	108	66	88	104	I	
P1	108	68	98	102	II	IIa
I1	108	72	94	104	I	
G1	112	70	80	100	II	IIb
F2	112	58	78		III	IIIc
K1	112	64	84	104	I	
E3	112	50	76		III	IIIa

Scan Line	Facet	Primary Mirror	Secondary Mirror	Tertiary Mirror	Group	Sub-group
D3	112	52	76		III	IIIa
B3	112	54	76		III	IIIa
C3	112	56	76		III	IIIa
M1	112	66	90	104	I	
A2	112	60	74		III	IIIb
J1	112	72	92	106	II	IIc
H2	110	70	82	104	I	
O2	110	62	96	102	II	IIa
L2	110	64	86	104	I	
E2	110	50	76		III	IIIa
D2	110	52	76		III	IIIa
B2	110	54	76		III	IIIa
C2	110	56	76		III	IIIa
N2	110	66	88	104	I	
P2	110	68	98	102	II	IIa
I2	110	72	94	104	I	
G2	114	70	80	100	II	IIb
F1	114	58	78		III	IIIc
K2	114	64	84	104	I	
E4	114	50	76		III	IIIa
D4	114	52	76		III	IIIa
B4	114	54	76		III	IIIa
C4	114	56	76		III	IIIa

Scan Line	Facet	Primary Mirror	Secondary Mirror	Tertiary Mirror	Group	Sub-group
M2	114	66	90	104	I	
A1	114	60	74		III	IIIb
J2	114	72	92	106	II	IIc

Referring now to Figs. 6-9, horizontal scan pattern 120, vertical scan pattern 122, and top-down scan pattern 124 are shown. Some of scan lines 26 appear to be curved. This is because scan beams 24 from spinner 16 do not lie in a flat plane; they lie on the surface of a shallow cone. The curvature of scan lines 26 represents the intersection of that cone and a particular intersecting plane (e.g., an aperture). The amount of curvature depends on the relative angle between the projected cone and this plane. Since the cone of light projects at different angles for the various scan lines 26, scan lines 26 may appear to have different curvatures.

Horizontal scan pattern produces Group III scan lines which emanate from horizontal aperture 28. Scan lines within Sub-group IIIa include B1-B4, C1-C4, D1-D4, and E1-E4. Scan lines within Sub-group IIIb include A1-A2. Scan lines within Sub-group IIIc include F1-F2. Side 130 of aperture 28 is the operator side.

Vertical scan pattern 122 (Fig. 7) produces Group II scan lines which emanate from vertical aperture 30. Scan lines within Sub-group IIa include O1-O2 and P1-P2. Scan lines within Sub-group IIb include G1-G2. Scan lines within Sub-group IIc include J1-J2. Side 132 of aperture 30 is the top side.

Top-down scan pattern 124 (Fig. 8) produces Group I scan lines which emanate from vertical aperture 30 and include scan lines H1-H2, I1-I2, K1-K2, L1-L2, M1-M2, and N1-N2.

Fig. 9 illustrates the combined scan lines emanating from vertical aperture 30.

Turning now to Fig. 10, bracket 15 may contain two lasers 140 and 142. Lasers 140 and 142 are preferably combined such that their laser beams are co-linear. This is accomplished by using a transparent window 144 with one partially reflective side 146. Window 144 is mounted on a support member and placed in front of laser 140 so that its beam strikes window 144 at a forty-five degree incidence angle. Laser 142 is oriented so that its beam is orthogonal to the beam of laser 140 and has a forty-five degree incidence angle with window 146. The resulting co-linear beams of both lasers 140 and 142 are parallel to and substantially co-linear with the path of the beam of laser 12 in the single-laser embodiment.

Additional lasers may be easily incorporated by adding additional windows. Bracket 15 may be easily modified to accommodate three or more lasers.

Preferably, lasers 140 and 142 are substantially identical and have substantially identical foci. The foci are preferably offset to increase the effective depth of field of scanner 11. Alternatively, the foci of lasers 140 and 142 may be different to enable scanner 11 to read bar codes of various spatial frequencies.

Although the invention has been described with particular reference to certain preferred embodiments thereof, variations and modifications of the present invention can be effected within the spirit and scope of the following claims.